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June 3, 1994

Ms. Donna R. Searcy
Secretary
Federal Communications Commission
1919 M Street, N.W., Room 222
Washington, D.C. 20554

Dear Ms. Searcy:

On behalf of Cornell University, transmitted herewith are an original and nine (9) copies of its Comments in response to the Notice for Inquiry in the matter of "Allocation of Spectrum Below 5 GHz Transferred from Federal Government Use" - ET Docket No. 94-32.

Should any question arise concerning this issue, please communicate with the undersigned at the Arecibo Observatory.

Very truly yours,

Dr. Willem A. Baan
Spectrum Manager, and
Senior Research Associate

cc: Dr. Daniel Altschuler, Director, Arecibo Observatory
Dr. Donald Campbell, Cornell University
Dr. Michael Davis, Arecibo Observatory
Dr. Tomas Gergely, National Science Foundation
Paul Feldman, Esq., Fletcher, Heald, and Hildreth
Michael Kimberly, Esq., Acting University Council, Cornell

BEFORE THE

FEDERAL COMMUNICATIONS COMMISSION

WASHINGTON, D.C. 20554

In the Matter of	)	
	)	
Allocation of Spectrum Below	)	ET Docket No. 94-32
5 GHz Transferred from	)	
Federal Government Use	)	

COMMENTS OF
CORNELL UNIVERSITY AND
THE NATIONAL ASTRONOMY AND IONOSPHERE CENTER

Cornell University ("Cornell") and the National Astronomy and Ionsphere Center ("NAIC"), which operates the Arecibo Observatory ("the Observatory") near Arecibo, Puerto Rico under the terms of a cooperative agreement with the National Science Foundation, hereby submit their comments in response to the Commission's Notice of Inquiry on the Allocation of Spectrum Below 5 GHz Transferred from Federal Government Use (the "NOI"), released on May 4, 1994.

I. Introduction

Cornell and NAIC recognize that the reallocation of portions of government spectrum, pursuant to the Omnibus Budget Reconciliation Act of 1993, is aimed at encouraging the development and use of new spectrum-based technologies. Cornell is pleased that the present NOI of the Commission emphasizes that the immediate reallocation of the required 50 MHz government spectrum should not result in a degradation of government and other spectrum use nor excessive costs to existing users. Cornell is furthermore pleased that the NOI recognizes Radio Astronomy as a valuable user of the spectrum, and emphasizes that the quality of the spectral regions allocated to the Radio Astronomy Service ("RAS") should not be degraded or jeopardized by the reallocation process of adjacent bands. Radio astronomy and other passive services are extremely vulnerable to interference and Cornell, as

operator of the world's largest filled aperture telescope, strongly supports all efforts of the Commission aimed at protecting the users of the Radio Astronomy Service.

Arecibo Observatory, which is part of the National Astronomy and Ionosphere Center (a federally owned national research facility), is the largest radio/radar telescope in the world and plays a leading role as a versatile research instrument in radiophysics. A Gregorian Upgrade initiative aimed at upgrading the telescope for higher sensitivity and lower system temperature is presently underway and is being funded by the NSF and NASA. The Upgrade program centers on the replacement of one of the two antenna/receiver houses by a Gregorian subreflector system allowing operation from 300 MHz to 10 GHz and higher. Arecibo Observatory has a mission to provide a highly competitive instrument for use by the astronomy research community in the United States and the world at large. The emphasis for the instrumentation has always been on high sensitivity observations combined with low noise receiver systems. The Gregorian Upgrade will dramatically increase the observing sensitivity and effectiveness of the telescope. Capitalizing on its great sensitivity, astronomers have successfully used the Observatory for detection experiments in radio astronomy and studies of bodies within our Solar System.

As explained below, Cornell is concerned about the future use of two to-be-allocated bands because they could cause interference to planetary radar studies and spectral line studies at Arecibo. Because of Arecibo's superior performance at these frequencies pulsar astronomers use these bands to study pulsar emission characteristics. The radar echos of planetary surfaces contain unique information about the surface properties, the orbit, and the size of planetary objects. This radar technique has been successfully applied to all nearby planets as well as comets and asteroids with exceptional resolving power and sensitivity. The Commission has recognized the importance of the planetary radar at Arecibo and suggests the placing of restrictions on use for the 2390-2400 MHz band[1].

II. Users of the 2390-2400 and 2402-2417 MHz Bands May Cause Interference in the 2370-2390 MHz Band

The present S-band radar at Arecibo operates at 2380 MHz using an instan-

[1]NOI at page 4.

taneous bandwidth of 20 MHz. Upon completion of the Gregorian Upgrade, the planetary studies at Arecibo will be done with a 1 MW S-band transmitter having double the power of the previous transmitter. This transmitter and the reflector's forward gain of 71 dB make Arecibo the world's most powerful radar. The doubling of the transmitter power and the lowering of the system temperatures will allow extremely high time resolution (0.1 microsecond) measurements of such objects as nearby asteroids. The potential danger to the Earth posed by small asteroids has recently received considerable publicity. The Arecibo 2380 MHz radar is one of two radar systems in the world capable of detecting these objects and providing the ability to predict their future orbits, and, for some of them, obtaining detailed images. Other achievements in this field include detailed maps of Venus, the recent discovery of ice caps on Mercury, and images of the large icy satellites of Jupiter. NASA's interest in the Gregorian Upgrade lies specifically with the increased capabilities of the planetary radar program at the Observatory.

Two particular frequency bands being considered for immediate reallocation are adjacent to the 2370-2390 bands used by radar astronomers for their observations at Arecibo. The NOI correctly concludes that the bands allocated for the radio astronomy service cannot be moved or reallocated. Radar modulation bandwidths of 20 MHz are needed at Arecibo to achieve the 15 meter (50 ft) resolution imaging capability for asteroids and comets. The very weak signals received are vulnerable to out-of-band emission from adjacent bands. The planetary radar system is used in a distinct transmit-receive mode employing coded pulse-train signals. As a result sideband emissions from users above the 2390 band edge could interfere with the detection and decoding of the returning signal from the planetary object.

Unfiltered sideband emission from the users of the to-be-reallocated bands adding only a few percent to the system temperature over the 2370-2390 MHz band of the Arecibo radar system can potentially result in a small but significant decrease in sensitivity for the system. A deterministic component within any unfiltered sideband emission could be very harmful for planetary radar observations. Such spectral structure could mimic the type of information to be received from the planetary surface and will be particularly harmful in terms of detecting weak signals from comets and asteroids. Circularly polarized emissions may further affect the essential polarization information in the planetary data and may inhibit a proper interpretation of this information.

Cornell is concerned that sideband emissions from powerful transmitters in both to-be-allocated bands may spill into the band used for planetary radar astronomy. Cornell urges the Commission to consider this aspect during the allocation process for these bands. Accordingly, if and when the Commission prepares technical and service rules for the use of both the 2390-2400 MHz and 2402-2427 MHz bands, Cornell requests that such rules include provisions for filtering the emissions from these bands in order to minimize emissions in the band used for planetary radar. In addition, Cornell strongly supports the Commission's suggestion of establishing additional constraints on land-based non-Federal operations near the Arecibo, Puerto Rico, Planetary Radar telescope in the 2390-2400 MHz bands as well as a prohibition of airborne or space-to-Earth links[2]. Cornell also supports an extension of these constraints to the 2402-2427 MHz band.

III. Harmonic Emissions from Services in the 2402-2427 MHz Band

Harmonic emissions from stations in the 2412-2418 MHz section of the 2402-2427 MHz band can fall within a 4825-4835 MHz band, where the RAS has secondary status internationally and US footnote protection[3] in order to protect spectral line and continuum observations. The RAS bands have been allocated to protect spectral line observations in bands where Nature dictates them to be. Formaldehyde is an important constituent of the interstellar medium and the 4.83 GHz and 14.5 GHz transitions are used to effectively determine the density of the emission region. Formaldehyde has been detected mostly in absorption within our Galaxy but recent studies at Arecibo have detected strong (for astronomy standards) emission in other prominent galaxies[4]. Formaldehyde emission from these galaxies reveal molecular gas in the very nucleus of the galaxy. Follow-up studies are in progress to study further the Arecibo galaxies with the Very Large Array[5] and further studies are

[2]NOI at page 4.

[3]Footnote US203 says "Radio astronomy observations of the formaldehyde frequencies 4825-4835 MHz and 14.470-14.500 GHz may be made at certain radio astronomy observatories as indicated below: (list follows which includes Arecibo Observatory). Every practicable effort will be made to avoid the assignments of frequencies to stations in the fixed or mobile services in these bands. Should such assignments result in harmful interference to these observations, the situation will be remedied to the extent practicable."

planned with the Upgraded Arecibo.

The harmful interference threshold for astronomical observations in this particular band has been presented by ITU/CCIR Recommendation 769[6]. This threshold is -230 dB(W/m^2/Hz) for spectral line observations. These limits are rather stringent because radio astronomy observations are conducted with the largest possible telescopes and the lowest noise receiving systems in order to detect the extremely weak celestial signals. The Gregorian Upgrade for the Arecibo telescope will increase the effectiveness of the Arecibo system at 4.83 GHz by a factor of roughly ten.

Cornell urges the Commission to consider the likelihood of second harmonic emissions during the selection of a service to occupy the 2402-2427 MHz in order to protect the 4830 MHz band. Considering that S-band transmission systems are less prone to harmonic emission than those at lower frequencies, a reduction of harmonic emissions below the harmful thresholds for RAS would not be an undue burden on the new occupants of the bands. Cornell urges the Commission to consider these arguments when selecting the users for the bands and to set strict standards to prevent transmitters in the to-be-allocated band from producing signals above the harmful thresholds in the 4830 MHz band.

IV. Conclusions

The Radio Astronomy Service and other passive services are the most vulnerable of all spectrum users. Cornell applauds the Commission for recognizing this vulnerability and for making continual efforts to protect the users of the band. Regarding the reallocation of the 2390-2400 and 2402-2427 MHz bands, Cornell supports rigorous conditions on out-of-band emission for the to-be-reallocated bands

[4]A 1993 scientific publication reports on the detection of ten galaxies with anomalous formaldehyde emission. This type of emission is thought to be an indicator of severe nuclear activity and provides a novel way to study the molecular gas in these spectacular nuclei. Increased sensitivity of telescopes like Arecibo will undoubtedly enlarge the group of formaldehyde emitters and promote studies of cosmologically interesting and distant sources.

[5]The Very large Array is one of the world's foremost radio telescope arrays and is located close to Soccoro, New Mexico.

[6]ITU/CCIR Recommendation 769 describes in detail the harmful interference thresholds for radio astronomy observations in various observing bands. The thresholds have been determined assuming that an interfering signal should not introduce an error of more than 10 percent. The response of a radio telescope has been standardized to represent differently constructed telescopes. The Arecibo telescope follows this standard representation very well.

for the protection and preservation of radar astronomy. Cornell supports additional constraints on land-based non-Federal operations within these bands near Arecibo, Puerto Rico, and a prohibition on the use of these bands for airborne and space-to-Earth links. Cornell also requests the establishment of strict standards for harmonic emissions from the 2402-2427 MHz band in order to protect the users of the 4830 MHz region of the spectrum.

Respectfully submitted,

CORNELL UNIVERSITY

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